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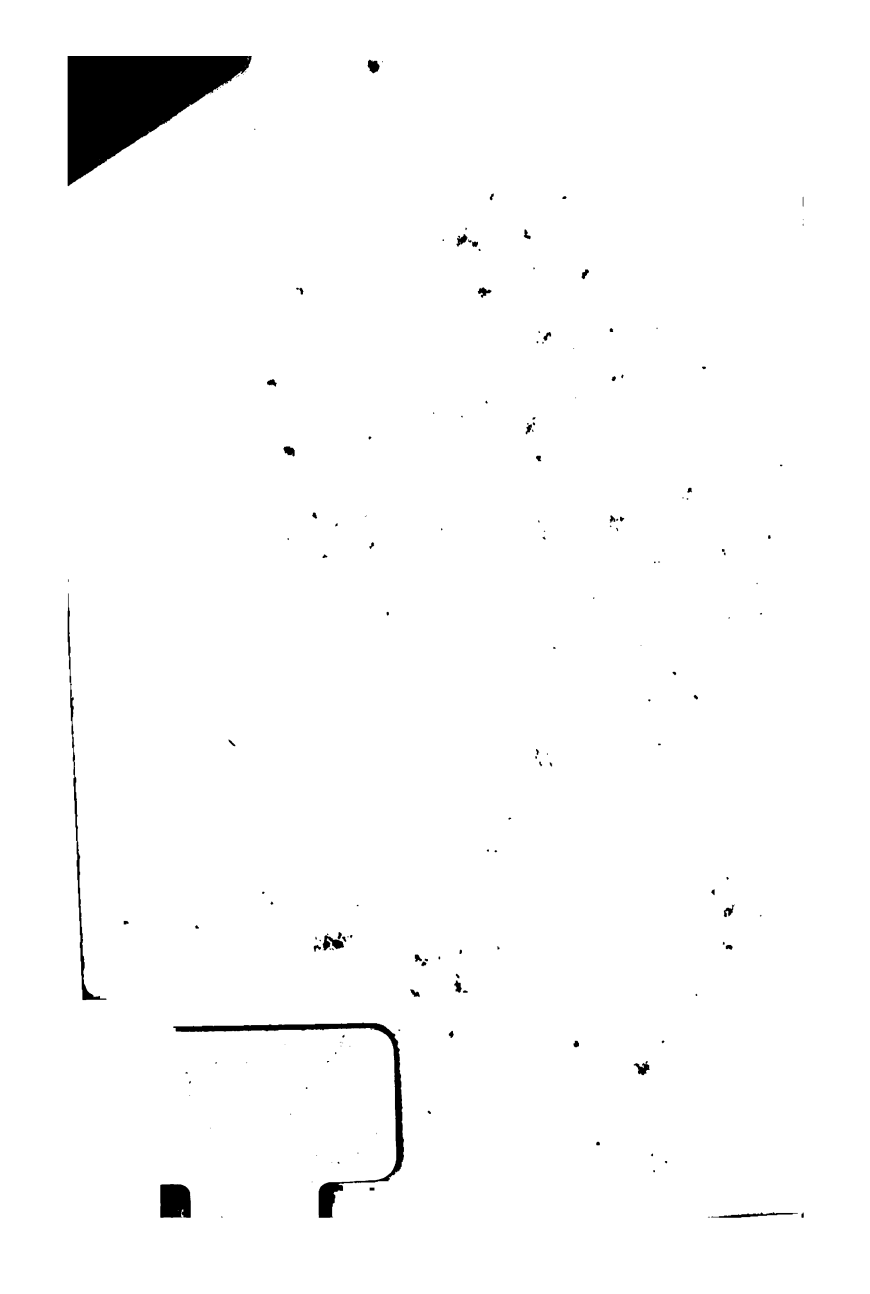

PRACTICAL HINTS

ON

ELECTROTYPE MANIPULATION

AND THE

ART OF MOULDING

IN

PLASTER, FUSIBLE METAL, WAX, GUTTA PERCHA, &c.

By J. B. HOCKIN,

OPERATIVE CHEMIST.

PART FIRST.

MOULDING—FORMS OF BATTERY—ELECTRO-DEPOSITION OF COPPER, WITH ITS APPLICATIONS.

LONDON:

PUBLISHED BY THE AUTHOR, 289, STRAND.

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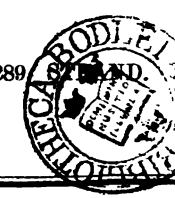

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PREFACE.

THE foregoing pages, with the exception of the last three, appeared originally in the columns of the CHEMICAL RECORD.

My intention in writing them was to supply a deficiency which I presumed to exist in the market, viz., that of a really Practical Guide to Electrotype in a small compass, and not overburdened with technicalities and abstruse chemical disquisitions; and one wherefrom a person totally unacquainted with the art might derive such information as would enable him to practise it with at least a tolerable amount of success. Whether I have succeeded in so doing is a question I must leave to my readers.

Should any point whereon I have touched not be deemed sufficiently clear to their comprehension, I shall be happy to answer any inquiries thereon. The next part will be devoted to the deposition of various other metals, the processes of gilding, silvering, &c.

J. B. HOCKIN,
289, *Strand*, *London*.

PRACTICAL HINTS ON ELECTROTYPE.

BY J. B. HOCKIN.

My object, in writing the following essay on the galvano-plastic art, not being to dilate upon its history, but simply to offer a few practical suggestions to those desirous of becoming acquainted with the results it is capable of affording, I shall refrain from entering into a description of the circumstances which led to its discovery, and content myself with merely stating that, in the year 1839, Messrs. Jacobi of St. Petersburg, Spencer of Liverpool, and Jordan, were simultaneously engaged in experimenting on the subject; and that the two former gentlemen published their results almost at the same time.

A subsequent discovery, first promulgated by Mr. Robert Murray, viz., the conducting power of plumbago—a substance whose almost infinite divisibility fits it for metallizing the surface of a non-conducting substance (however fine its lines)—has extended its sphere of application far beyond bounds which, without this, it would have ever attained.

Nor should be omitted the name of Mr. Alfred Smee, as one among the earliest experimenters, and who, by his extended investigations, and logical deductions therefrom, has, perhaps, done more than any other towards elucidating the laws which govern the electro-deposition of metals.

Before plunging *in medias res*, a little time may be profitably spent in glancing at some of these laws, and at the various forms of apparatus contrived for the purpose of applying them to practice.

1. On immersing a strip of commercial zinc into dilute sulphuric acid, it will be observed gradually to waste away, and at the same time to become covered with numerous bubbles of a gas, which, rising to the surface of the liquid by its superior lightness, may be there collected by means of an inverted test-tube, filled with water, which the gas displaces. On applying a light to the tube, removed from the liquid, the contents will burn with a flame almost devoid of illuminating power, a circumstance which proves it to be hydrogen; and this must necessarily proceed from the decomposition of water, the only source of hydrogen present. Now, as water is a compound of this gas and oxygen, the latter (being set free) combines with the zinc to produce an oxide, which dissolves in the sulphuric acid employed, and produces sulphate of zinc.

2. If we now plunge into the same liquid a piece of copper, silver, or gold, and cause it to touch the zinc at any point not covered by the fluid, we shall have what is called a voltaic or galvanic couple, pile, or battery, and we shall find that the hydrogen is no longer eliminated on the surface of the zinc, but on that of the copper, or other metal employed.

3. On the addition of a few drops of sulphate of copper solution, the hydrogen will be no longer visibly disengaged, but will react on the oxide of copper (contained in the sulphate) (*vide* Sec. 1), abstracting its oxygen, and thereby precipitating the metal at those points where the hydrogen would have shown itself.

4. If, instead of causing the two metals placed in the

dilute acid to touch each other, as in Sec. 2, we attach them the one to the other by a stout copper wire, the result will be the same. On dividing this wire in the centre, and placing the two free extremities beneath the surface of the copper solution, contained in *another vessel*, the hydrogen is, as at first, eliminated at the end *attached to the zinc*, there precipitating metallic copper; while the other, like the zinc in the first experiment, is gradually oxidated and dissolved.

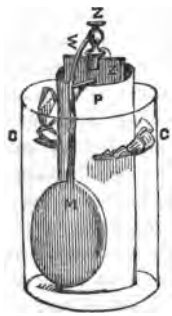
5. Experiment No. 2 explains the theory of all the galvanic batteries hitherto discovered which are practically useful; and Nos. 3 and 4 may be taken as true types of all the metallurgic operations comprised in the general term—electrotype, or galvano-plastics.

6. The zinc in these arrangements is said to be the *positive* metal, and the copper the *negative*. The following table shows the relation in which some of the metals stand towards each other, when combined in couples in contact with dilute acids, the first in the list being the most *positive*, and the last the most powerfully *negative;* and, of any two of them, that one first occurring will be positive with regard to that last found; and, the greater the distance which separates them therein, the larger the quantity of electricity will they furnish on being made the elements of a voltaic arrangement:—

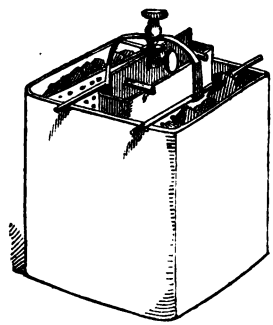
TABLE.

Positive.	Bismuth.
Zinc.	Nickel.
Cadmium.	Silver.
Tin.	Antimony.
Iron.	Gold.
Lead.	Platinum.
Copper.	*Negative.*

ties, viz., carbon, copper, &c., each particle of which, acting as the negative metal, causes the effect we have just seen; the mercury acts by enveloping these, and preventing their contact with the zinc, and consequent injurious action thereupon.



No. 1.



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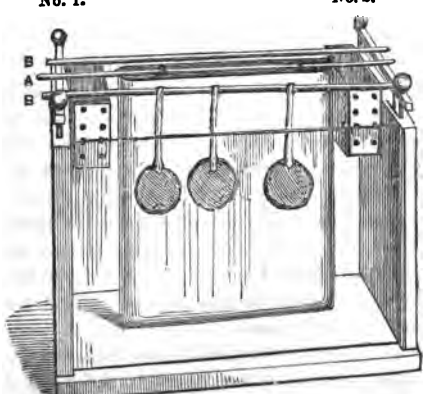


No. 3.

12. The most simple form of apparatus is the *single-cell* arrangement represented above. This consists of an exterior vessel (vide cut 1) made of glass, porcelain, stoneware, or gutta percha, filled with an acid solution of sulphate of copper: P, a porous cylinder of unglazed earthenware, or, better, of biscuit porcelain, containing dilute sulphuric acid, in which is immersed a strip of amalgamated zinc, supported by a glass rod; to this, by a *binding screw*, S, is attached the connecting wire, W, which serves to suspend the mould M,* to be covered with the deposited copper; C is a perforated diaphragm to contain the supply of crystals of sulphate.

It will be observed, on a little reflection, that here the principle is identical with that enunciated in sect. 2 and 3. We have the positive metal in contact with an acid liquid, and the negative represented by the mould, and the two united by the connecting wire. The object of using the porous cylinder is to prevent contact between the sulphate of copper and the zinc, as the latter, having more affinity for oxygen than the copper has, would abstract it from the oxide in the sulphate, precipitating the metal, and thus form a galvanic couple on its own surface. Now, as the electric current, other circumstances being equal, always chooses the shortest road, very little of it would pass along the conducting wire to the mould.

13. To choose the right degree of porosity is here of the greatest importance, as, if its substance be too pervious, the liquids will mingle; if, on the contrary, it be too close, such an impediment will be offered to transmitting the current that the deposition will become

* *Mould* is here used in its widest signification, meaning any surface we wish to cover with deposited metal.

exceedingly slow. For small apparatus the material previously mentioned is the best, but, when it is required of large dimensions, veneers of beechwood, $\frac{3}{16}$ inch thick, or inferior descriptions of sole leather, are found to produce very good results.

14. Figure 2 is a representation of a very convenient form of single-cell apparatus: the external cell is of Wedgwood porcelain, a material very little affected by the copper solution, and in this, it will be perceived, the porous cell is a long oval, thus occupying but small space, and affording room for a large plate of zinc.

15. Figure 3 is a wooden case, having its sides of glass, and rendered water-tight by *marine glue* or *electric cement*, the latter being a compound of 12 parts resin and one part each wax and tallow. It will be perceived that here the connecting wires are arranged in a somewhat different manner from the former. The zinc is suspended by copper hooks to a brass rod, A, the ends of which rest on a metallic framing at right angles to it, which serves to connect it with the wires BB, from which depend the moulds attached to ribbons of copper.

16. Various modifications of these forms, and of materials, suggest themselves readily, after attentively studying those already indicated. The juvenile electrotypist will, perhaps, be content to make his first essays with an ordinary jelly-pot, a small porous cell, a strip of zinc, around the top of which a copper wire is twisted, and a few crystals of sulphate of copper enclosed in a piece of linen; and, even with this rough arrangement, excellent results may be obtained.

17. Ordinary earthenware should not be used, where duration of apparatus is an object, as the copper solution soon penetrates through the glaze, and, crystallizing on

the outer surface, soon reduces the containing vessel to a very friable condition. Glass and porcelain are the most suitable for constructing small apparatus. Wood lined with marine glue (a compound of shellac and indiarubber) or with gutta percha is, perhaps, the best for forming large cells. The method of extending the former substance is to melt it in an iron pot, constantly stirring until it becomes fluid; then, pouring it over the interior of the box, previously *heated*, smooth it by an iron rod moderately hot. Its moderate price (about 1s. per lb.) renders this substance of peculiar benefit to those who electrotype on a large scale.

Gutta percha sheet $\frac{1}{16}$ to $\frac{1}{8}$ inch thick should be held before the fire until its surface becomes adhesive, and then applied with considerable pressure to the sides of the wooden trough, heated strongly as in the former instance, the joints being seared afterwards with a hot iron. Stoneware and slate troughs last well for a time, but finally become disintegrated by the searching influence of the sulphate.

The *single-cell* apparatus being the form best adapted for precipitating copper from its sulphate, and this metal being more suitable than any other in reproducing objects by the electrotype, I shall, before describing other forms of battery, proceed to illustrate the method of operating with it.

20. Procure some sulphate of copper free from contamination with sulphate of iron (known by the crystals being of a uniform dark blue colour, and having no small green efflorescence in their interstices: or by their dissolving with but little residue in liquid ammonia); mix $1\frac{1}{2}$ lb. with a half gallon of warm water, and stir until dissolved: allow the liquid to stand until it becomes quite clear, then pour off from the deposit, and add

to it one-sixth its measure of water containing a wine-glassful of sulphuric acid. If a film, having a greasy appearance, be seen on the surface, it should be removed by a piece of thick blotting paper held by one corner, and slowly drawn across until it all disappears.

21. A metallic mould presenting the fewest difficulties for an illustration, let us suppose we wish to obtain a copy in reverse of a penny piece. We first proceed to render the side we intend to electrotype clean and bright; this we effect by the aid of a hard plate-brush and finely-sifted rottenstone moistened with a few drops of olive oil, and finally wipe off all trace of grease with some cotton wool. We then either encircle the coin with a fine copper wire, or attach it to the back by soldering, and with a soft plate-brush and black-lead cover the side to be copied with an exceedingly thin coating of plumbago, which will effectually prevent adhesion between the deposited metal and the cleaned surface; the back and rim should be covered with wax or varnish (an excellent one for the purpose, and of great use in this art, is one ounce of sealing-wax dissolved by agitation in three ounces of spirits of wine or wood naphtha), that the deposited metal may not extend over these parts and entomb the mould in a mass of copper: this it prevents in virtue of its being a bad conductor of the galvanic current, which, in order that it may produce its decomposing effect on the copper solution, requires the aid of good ones. The metals and carbon, especially in the form of graphite or plumbago, possess so pre-eminently the latter quality that we are accustomed to speak of them as *conductors*, and to distinguish other solids, particularly the resins, fats, wax, stearine, &c., as *non-conductors*.

22. The mould having been thus prepared, a mixture

of water with a few drops of sulphuric acid is put into the porous cell, which is then placed in the sulphate of copper solution. A piece of amalgamated zinc is procured of such dimensions that the part immersed in the acid liquid corresponds in superficies to the surface of the mould: the latter is then attached to the binding-screw by means of the wire joined to it, and immersed in the liquid, as in Fig. 1; or the connecting wire or band is hooked at its extremity and made to depend for *metallic contact* on its own weight resting on the connecting rods BB. *Vide* Fig. 3.

23. Certain precautions are necessary to prevent the mould from carrying down *air bubbles* with it when plunged into the liquor, which it is prone to do from the great attraction always existing beetween smooth surfaces and the atmosphere—a good exemplification of which may be seen in any plate-glass warehouse, where whole sheets, after being raised on their edges, are allowed to fall flat on the table without any risk of breakage, from the fact that the air is retained so forcibly by the flat glass and the surface of the bench that it does not escape as fast as the glass falls; consequently, it becomes compressed by the weight, and acts as a spring in preventing any violent concussion of the falling slab.

These *air bubbles*, if allowed to remain, would be speedily covered by the copper, and would produce very unsightly depressions in the electrotype copy when detached from the mould: their formation is, in great measure, prevented by breathing on the mould before immersion, and by this means covering it with a film of water, which, displacing the air, enables the liquid to wet the whole surface immediately it is immersed. If, however, the object be in high relief, or the contrary,

brush over it a solution composed of dry chloride of platinum 1 grain, water 1 oz.; well rinse in water, and wipe with a soft cloth. This produces a fine rich olive tint, which may be deepened down to black by using a larger proportion of the platinum salt.

Black-lead Bronze.—None, however, of the various methods of bronzing, which are so numerous that it would be tedious to enumerate half, are capable of affording so good and such varied results as plumbago; it possesses, moreover, the advantage of being perfectly under command, may be stopped at any point, and, if not satisfactory, can be washed off and recommenced.

The object to be bronzed should be cleaned with oil and rottenstone, as before described, the oil partially wiped off by means of some cotton wool, and immediately carefully black-leaded, without using too great a degree of friction; it must be then heated to within a few degrees of the temperature necessary for burning the hair of the blacklead brush, and polished off, using great friction. The tint will depend upon the quantity of oil allowed to remain, this enabling the surface to retain more of the blacklead, consequently to appear of a darker colour. The effect is very fine, and gives high relief to the prominent parts, from their getting so much more polish than the hollows, thus obviating the disagreeable effect which all unbronzed bassi relievi produce by reason of their metallic glare. I shall, however, leave for the present the subject of bronzes, to revert to them again when treating of the reproduction of statues, in which their application is of the highest importance.

27. The next branch of our subject to be treated of is the important one of *mould-making*, and the various substances in use for effecting this object. None of these give such excellent results as that we have just

been studying, the forming a mould directly from the object itself by the electro process, but this is, in many circumstances, impracticable; and in others—that, for example, of a rare and ancient medal, whose surface the friction necessary for cleansing would deface—ineligible. These substances resolve themselves naturally into two groups, the *metallic* and *non-metallic*. Of the former, besides that already described, the use of sheet lead, planed down to a smooth surface and applied under powerful pressure to the surface to be copied, gives good results, where extreme accuracy is not an object, and the relief is not great, nor the substance likely to be injured by the compression necessary; this is, however, a combination of circumstances sufficiently rare to warrant my not enlarging farther on this method. Very thin sheets of metal—as tinfoil—may be used in the same manner as the above, but their great flexibility prevents their obtaining any practical importance.

28. *Fusible Metal Moulds* are those which offer the greatest number of advantages; of these *type* metal presents a good example; but, owing to the high temperature necessary for its fusion, and the amount of practice required for its manipulation, it has obtained but small favour in the eyes of the electrotypist. The best for this purpose is composed of 8 parts bismuth, 8 lead, and 3 tin: these ingredients should be melted together in an iron ladle, at a heat just sufficient to cause their combination, stirred for a short time with a hot iron rod, poured out on a piece of wood, drop by drop, to favour their speedy cooling, again melted and re-melted two or three times, in order to produce perfect uniformity in the mass.

When required for use, the alloy must be melted in an iron utensil, at a heat not greatly exceeding its point

of fusion, about 226° Fahrenheit; poured into a paper capsule, stirred with two pieces of card until it assumes a pasty appearance, and the coin or medal *not warmed* dropped on to its surface from a height of three or four inches. Success in this process depends on the operator having carefully divested the surface of the fluid metal of every trace of oxidation, and upon his seizing the exact moment when it is passing from the fluid to the solid condition. For it we are indebted to Mr. C. V. Walker.

29. Large medals are better taken by the following means:—Procure a piece of wood half an inch thick or more if required with a circular depression turned in it corresponding in diameter with the medal, and half its depth; wedge the medal tightly into this, heat it until it can scarcely be borne by the hand, place it on the surface of the metal, treated precisely as in the last instance, administer a short quick blow with the fist to the wooden backing, and continue pressure until it is nearly cold; it should be completely so before separating the mould. Moulds obtained by this method are called *clichés*. The process requires great practice to ensure success, and is expensive, from the oxidation of the metal which takes place every time it is remelted.

30. Of *Non-metallic Substances* our repertory affords a much greater choice than of the metallic; among them sealing-wax, plaster of Paris, wax, stearine, resin, and gutta percha, are best fitted for electrotype operations.

Sealing-wax is peculiarly adapted for taking impressions not exceeding one inch in diameter; the finest quality, that used by the engravers, is the most suitable. It should be melted in the spirit-lamp, care being taken not to allow it to inflame, wiped off as it softens on to a piece of good writing paper, until sufficient has been

accumulated, then held over the flame, stirring constantly with the stick of wax until it appears uniformly fluid; it should then be placed on a smooth flat surface, the seal or medal pressed forcibly on it, and the pressure continued until it has become nearly cold. If a small wine or liqueur glass be now inverted over it, the disagreeable curling often noticed in large seals will be avoided.

Plaster of Paris is an exceedingly valuable material for our use, it being applicable to subjects of any size or form. We employ the finest quality only, that used by the Italians, who are the chief cultivators of *plaster-casting*, as it is termed. If it have been exposed to the air some time before using it should be heated over a slow fire until the heaving which is first produced has nearly subsided, sprinkled into some water in a saucer until sufficient is added to produce a thin cream, then stirred gently to produce an uniform admixture, and a small quantity poured over the surface of the object, previously slightly oiled, and having its edge surrounded with a fillet of oiled paper, to form a receptacle for the fluid plaster; it should be then wiped into the depressions by means of a brush (to detach air bubbles, and cause it to penetrate the fine lines), and, before it hardens, a sufficient quantity of plaster poured in to give the cast the desired thickness. Within half an hour it may be detached, and placed to dry in an oven, or on a stove, at a temperature not much above the heat of boiling water. These casts are equally sharp with the originals whence they are taken, owing to the expansion the material undergoes in the act of *setting*, as it is termed, or, more properly, combining with the water, and forming a crystalline mass. The addition of a piece of alum the size of a hazelnut

to each pint of water, previous to its admixture with the plaster, tends materially to harden the cast.

Plaster casts, and other very porous bodies, require soaking in a drying oil, as linseed oil, before they can be copied by this method.

White wax, *beeswax*, and *stearine* are bodies which enjoy a considerable share of consideration from the electrotypist; no one of them, however, unites all the qualities essential to the production of a good mould, wax being very liable to crack, and stearine being too crystalline. The following compound possesses in a high degree all the necessary good qualities, viz., toughness, evenness of surface, hardness, &c., and does not contract in cooling nearly as much as its ingredients taken separately:—Take of white wax 1lb., stearine ½lb., flake white, or litharge, 1 oz.; melt the whole together over a very slow fire, stirring constantly for half an hour; allow it to rest until the excess of lead has precipitated, pour off from the residue into a clean dish, and preserve for use.

If required for immediate use, 2 oz. of lead plaster, to be procured of any druggist, may be substituted for the above compounds of lead. The qualities of this mixture are enhanced by age and frequent meltings.

Resin and Tallow, mixed in equal quantities, or in other proportions, form an useful compound for taking moulds of large objects where extreme fidelity of reproduction is not required, and the comparatively high price of the wax compounds would prove an objection to their use; it is, however, liable to become granular after frequent remeltings, consequently cannot be employed in many successive operations. The resin should be kept melted over the fire until the ebullition, which at first occurs from the escape of water always present in the commer-

cial article, has ceased; then taken off, and the tallow added; the heat retained by the vessel and its contents is generally sufficient to melt the latter; should this not be the case, it will be necessary to employ a little more heat. Great care is required to prevent inflammation, from the highly combustible nature of the resin vapour.

The method of obtaining a mould with any of the above fatty and resinous bodies will necessarily vary with the material of which the object to be copied is composed. The following instances will serve as types for all:—

31. To procure a *wax composition* mould of a metallic surface—a medal, for example—melt the wax in an earthen vessel over a very slow fire, or, better, over a steam or water bath;* having carefully cleansed the surface, oil it slightly with a little sweet oil and cotton wool; encircle it with a fillet of moistened letterpaper, extending above the medal sufficiently to form a reservoir to contain the fluid, and tied with string tightly round the edge to prevent any escape; heat the medal to near the boiling point of water, and, placing it in a slightly-inclined position, pour the wax on it in a continuous stream, commencing at the lowest edge, until sufficient has been accumulated to give the necessary thickness: about one-third of an inch is sufficient depth for small moulds under one inch in diameter. The wax should not be poured on too hot. When it begins to set around the edges of the containing vessel, but still retains heat enough in the mass to remelt the solidified portion, it is in the state best adapted to avoid risk of failure from wavy lines, produced by too

* This is constructed by placing an evaporating-basin over a saucepan containing water, which is made to boil: if it touch the basin it constitutes a *water bath*; if not, a *steam bath*.

quick cooling, on the one hand, and from cracking, arising from contraction, on the other. When it has set, the paper rim may be removed, and the whole allowed to cool completely ere you proceed to separate the mould; this should be effected almost spontaneously by gently pulling at right angles to the surfaces. If adhesion has taken place, we may sometimes succeed in separating them by slightly warming the medal; but more frequently this indicates a failure, as the metallic portion cannot be induced to leave the wax without detaching a portion, and in many cases denotes that the preliminary cleaning has not been sufficiently attended to. It will be evident that this process cannot be applied to surfaces at all undercut, nor to old medals honeycombed by time; nor is it of use where absolute identity between the original and the copy is required, as the contraction effected during the cooling of the mould renders it somewhat smaller than the original; this, however, being pretty uniform, does not render the discrepancy visible except upon comparison of the two.

32. Plaster casts, and porous bodies insoluble in water, should be saturated therewith previously to having the melted material poured on them. To this end, the plaster, previously warmed, should be put into a dinner plate, with the face upwards, and boiling water poured in carefully, to avoid splashing it over the surface, until it rises to within the eighth of an inch thereof; it will be rapidly absorbed, and appear, in obedience to capillary attraction, on the face of the cast, which, when nearly covered by small globules of water, must be taken out, encircled with paper or lead foil as above directed, and, being freed by drying from the last trace of visible moisture, treated as the metallic body in the previous section. Portions of plaster are very apt to detach

themselves from the cast, and remain on the mould: they may be removed by dropping on them a little sulphuric or nitric acid, diluted with an equal volume of water, allowing it to remain some hours, then washing off with a camel-hair pencil and abundance of water.

These moulds are seldom perfectly satisfactory: plaster of Paris is not absolutely insoluble in water, and the small quantity which rises to the surface carries with it a portion which it deposits in a pulverulent form on evaporation, thus destroying the brilliancy of the polish: bubbles of air, also, which have not been displaced from the interior of the mould by the water, rise when the wax is poured on, and, if not dislodged by a few smart raps administered to the cast before it is allowed to cool, would remain and entirely mar our success.

33. *Gutta percha* is the substance which, next to metal, reunites the greatest number of good qualities, and, in some instances, even surpasses it. When a surface is slightly undercut the semi-elasticity of this substance enables it to be pulled away from the model, without either losing its proper shape, or defacing the original, unless extreme violence be used. Small subjects, as seals, may be impressed directly, as upon sealing-wax, the gutta sheet having been sufficiently softened by heat; larger ones, not very high in relief, should be first warmed, placed on a flat surface, and sheet gutta percha, previously dipped until it becomes quite soft into boiling water, laid carefully on them, pressed with the hand into contact with their surface, and the whole then transferred to a press, and kept there until nearly cold. In default of a screw-press, heavy weights may be used to effect the object.

Printing type, wood blocks, and engraved plates, may be copied in the most perfect manner by this means, without risk of injury to the originals. In the case of type great pressure should not be employed: the gutta being forced too far into the interstices between the letters, forms such depressions in the mould as obstinately retain air bubbles, and thus prevent our obtaining a perfect cast adapted to printing. If the object be in high relief, the following method is the most eligible for copying its details:—Let the gutta be boiled in water until quite soft, then carefully freed from moisture by pressure in a cloth, rolled into a ball, and assiduously pressed with the hand into all the sinuosities of the model, commencing in the centre, and gradually extending the pressure, so as to drive the air before it, until the edge is reached, when it may be transferred to the press, or heavy weights placed on it as before mentioned. I have every reason to conclude that those French cigar and card cases, purses, &c., ornamented with electro-silvered copper casts, lately introduced into commerce, are produced from gutta percha moulds; and certainly, if this be the case, they form a very fine illustration of the capabilities of this substance in the application of the electrotype to practical purposes.

While engaged in speaking of gutta percha, I must not omit to mention the advantages in the study of natural history to be derived from its use. Galvanic copies of leaves, ferns, and other vegetable productions which can be laid on a flat surface and submitted to gentle pressure, are easily obtained, and reproduce the object with great fidelity. Its utility in the copying of rare fossils was beautifully displayed in the Austrian portion of the Great Exhibition.

34. When a subject is very much undercut, it re-

quires the mould to be made in separate pieces; but this operation is one not likely to be undertaken by the amateur, and is too difficult to be explained in a treatise like the present. Such is also the case with the modelling from a bust or statue.

35. It is greatly to be desired that an elastic material were discovered which should be insoluble in water, and non-absorbent of the various saline solutions used in the electro process. The only one with which I am acquainted, as practically useful, is that of which the printers' inking-roller is composed, viz., twelve parts of glue, melted and mixed with three of treacle; this separates very readily from the original, if oiled, but cannot be immersed in any aqueous solution. It is sometimes employed for taking moulds of busts, &c., in one piece, in the following manner:—The bust, if of plaster, having been impregnated with oil, and with the orifice at its base closed with paper, is suspended in an inverted position in a glass vessel just sufficiently wide to leave a space of half an inch to an inch between it and the model; the melted composition is then poured in, air bubbles detached by means of a feather, and the whole allowed to rest until cold, when it readily separates from the glass vessel. The operator then places it to stand on its base on the table, slits it down the back with a knife, and holds it open, while an assistant lifts out the cast. It is then reclosed, tied round with twine, placed for support in the former vessel filled with sawdust, and a duplicate of the bust obtained by pouring in wax melted at a heat so low as not to melt the composition. The *facsimile* produced may be used to produce an electro-mould by means hereafter explained. Considerable practice and delicacy of manipulation are necessary before any good result can be expected in this process.

36. As I have before stated, the electro action, as far at least as the art we are now studying is concerned. is only visible when the substance is a good conductor. In cases where it is the reverse, we must apply some such material to them that they may be fitted to receive the metallic deposit. Various compounds have been used at different times, such as gold and silver leaf and bronze powders; but that which has undoubtedly advanced the art to the high degree of utility which it now has is plumbago—a natural product, and well known as one of the forms of carbon (not carburet of iron, as many have asserted, the iron being present only as an accidental impurity). This substance varies very greatly in quality, and to be enabled to judge of this is of the greatest importance to the student of electrotype. The only perfect test is the reducing it to practical proof of its efficiency. There are, however, many indications whereby we are enabled to estimate its value. It should not feel hard or gritty between the fingers, but should readily cake on being pressed between them; and, on their being rubbed together for some time, should break down into a lubricating fine powder, void of all asperity. That used for domestic purposes is never sufficiently fine for our use.

37. *To blacklead a wax mould*:—Procure a brush similar to that used for cleaning plate by the jewellers, and as soft as possible; sprinkle a quantity of the powder over the mould, and rub it assiduously into all the depressed portions, avoiding the use of too great pressure, or the evolution of heat from too long friction. When it appears blackened all over, shake off what remains non-adherent; and polish off with the brush alone. If in any part the wax is not covered, breathe on the portion; brush on some more blacklead until the

desired coat has been obtained. Upon the attention bestowed on this operation depends, to a great extent, success in the subsequent ones. The greatest care is required in the very deep parts, as it is these which so frequently obstinately persist in resisting the extension of the metallic deposit, and being necessarily the most prominent portions of the model, are those which demand the most perfect execution. The flat portions seldom fail in covering. Sealing-wax generally requires to be moistened with a minute quantity of spirits of wine ere it will take the blackleading; this must be done very carefully, otherwise the fine parts are liable to be defaced. Gutta percha takes very readily a thick coating, and becomes nearly as useful as metallic moulds when thus rendered a conductor.

38. The difficulty which attends the brushing of black-lead into deep depressions has caused considerable experimentation to be directed towards the reduction of certain metals from their solutions on the surface intended to be covered with copper, &c. The following summary will detail a few of the methods which have been found to succeed:—

Solutions of the precious metals, gold, silver, and platinum, are those with which success is more certain; of these, silver, being the cheapest, is most generally employed.

1st, One part phosphorus dissolved in four parts of bisulphuret of carbon is added to 100 parts of wax composition, free from lead, and the mould made therewith dipped into a solution containing 50 grains of nitrate of silver in the ounce of distilled water; the liquid, caused to penetrate into the crevices by means of a feather, deposits its silver in the metallic form on the face of the mould, and effects an excellent conducting

surface, which may be rinsed with water and immediately transferred to the copper solution. This process is not applicable to objects which, like plaster, would decompose the silver solution. The solution of phosphorous is also an extremely dangerous compound; if, previous to being mixed with the wax, one drop be spilled on the clothes or person, it will spontaneously inflame on the evaporation of the bisulphuret. Burns produced by it are extremely painful and difficult to heal.

2nd, One drachm of nitrate of silver dissolved in one ounce of water is brushed with a camel-hair pencil into every portion of the wax model, until it is entirely covered; the subject is then enclosed by a glass shade and non-inflammable phosphuretted hydrogen (generated by twenty grains of phosphorus heated in a retort with one ounce of spirits of wine and 30 grains of caustic potash) passed in until the perfect reduction of the silver. To those unacquainted with chemical manipulation it may be needful to explain this process a little more clearly. Procure a stoppered retort, or, what will answer as well, a large test tube, with a bent tube attached to it; place in it the alcohol, add thereto the potash, and when solution is effected, the phosphorus, cut into small pieces; the end of the retort, or exit tube, being now passed a little way under the lower edge of the glass covering the model, a slight heat is to be applied to the mixture, the gas generated will pass into the receiver and precipitate the silver as has been before explained.

3rd, Dissolve 80 grains of nitrate of silver in four ounces of pure water, and the same quantity of neutral tartrate of potash in two ounces of water; add the latter solution to the former, stir well for a minute,

throw the product on a piece of calico stretched over a wooden frame, and allow the liquid portion to run off; wash the precipitate remaining by the gradual affusion of six ounces more water, press out nearly all the remaining liquid, and add to the semi-fluid residue sufficient ammonia to redissolve it. This operation, being performed without exposure to direct daylight, should produce one ounce of ammonio-tartrate of silver solution. This, on being brushed over the object to be metallized, whether of wood or plaster saturated with wax, and exposed to direct solar action, decomposes very rapidly without requiring any other precipitant, and will be found to produce more uniformly good results than those above-mentioned, without their danger or giving off any offensive emanations.

4th, The ammonio-nitrate of silver, made by adding ammonia to a strong solution of nitrate of silver until the precipitate at first produced is re-dissolved, may be used instead of the tartrate, but is liable to produce the fulminating compound when kept, and is not so readily decomposed by the solar influence.

39. As before observed, the silver in these operations is reduced to the metallic state, but rarely possesses any brilliancy; it is more commonly thrown down in the state of a black powder, which, however, conducts electricity most perfectly. Immersion in the copper solution should speedily follow the perfect reduction, as the silver film is quickly attacked by sulphureous vapours always present in the atmosphere, especially near large cities, and thus rendered inferior in its conducting powers.

I shall now, having described at length the method of preparing almost every substance for receiving the metallic deposit—proceed to illustrate the construction of

the few forms of battery which are employed in this art, and their management when in use.

40. As I have before mentioned, the single-cell process is best adapted to general purposes in the depositing of copper from its sulphate; but there are circumstances where the use of a separate battery is necessary: for example, in the case where the subject is in high relief—the raised portions, being much nearer to the source of the electric current, the zinc, obtain a larger share of the action than those which are depressed; the latter consequently are very difficult to cover completely. In the commencement of the work I described the principles involved in the two forms, viz., the single cell and the separate battery: and it will be remembered that the latter requires that the liquid to be electrolyzed be contained in a vessel separate from the battery cell—this we call a *decomposition trough;* and I may remark *en passant* that the size of the latter need bear no relation whatever to the size of the battery, as the quantity of liquid it contains does not in any way influence the result, this depending upon laws which will be explained in their due course.

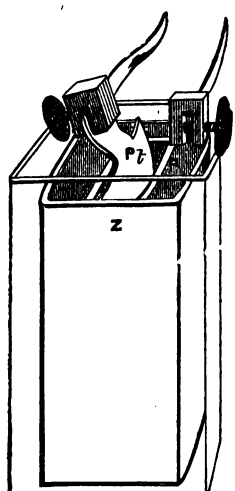
41. *Professor Grove's Battery* is the most energetic form with which I am acquainted. It is composed of a plate of platinum immersed in a porous cell, either round or flat, containing strong nitric acid; outside the porous vessel, and in contact with a mixture of one part sulphuric acid, in ten parts water held in a vessel of glass or porcelain, is a sheet of thick flatted zinc. To each metal is attached by soldering a *binding screw*, which serves to connect it with a conducting wire; these screws and wires should be covered with a thick coating of silver, to protect them from the influence of the nitrous fumes, which are plentifully evolved from

the nitric acid used, in virtue of its decomposition by the hydrogen, eliminated under the influence of the laws enunciated in sections 2, 3, and 4.

The Chevalier Bunsen has introduced a valuable modification of this apparatus, substituting for the platinum plate, which is costly, and liable to be dissolved should the nitric acid contain any hydrochloric (which the ordinary commercial usually does), a cylinder of carbon. For the manufacture of this the following method is generally adopted :—a hollow cylinder of sheet iron, closed at the bottom, and having a cover fitted to the top, is filled with a mixture of two parts coke and one part coal, both finely powdered and sifted ; an iron bar (surrounded with thin cardboard), whose diameter is somewhat larger than the porous cell intended to be used in the battery, is now forcibly pushed down through the loose mass until it reaches the bottom, and, the cover having been luted on, the apparatus is exposed to a very high temperature until the production of gas has entirely ceased ; on allowing it to cool, and extracting the resulting coke, it will be found to constitute a hard hollow cylinder ; this should then be dipped into treacle, allowed to dry, and again carbonized in a clay crucible filled with powdered coke, and its cover luted down. The resulting mass treated with dilute nitric acid is very pure carbon, possessing high conducting power, and is capable of effectually replacing the platinum in Groves' arrangement.

41 (*a*). A peculiar form of carbon which is found lining the interior of gas-retorts, has been found very suitable for this battery, but its refractory nature and extreme hardness are great impediments to its extended application.

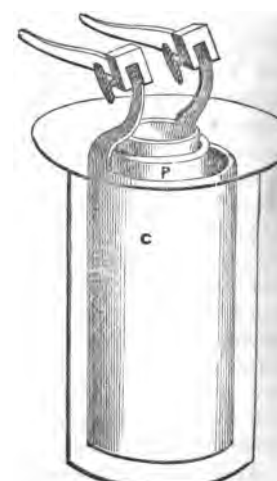
42. Professor Daniel's battery, as will be perceived on referring to the cut (Fig. 6), is that which has suggested the more generally used modification of the single cell apparatus; they are in fact, when in action, identical. Some persons have gone so far as to assert, that it is to this battery that the art of electrotpye is due; this position has, however, I believe, been quite abandoned. It consists of an exterior cylindrical vessel of copper, 3½ inches in diameter, which contains a solution of sulphate of copper, similar to that previously described in



GROVE'S BATTERY.

FIG. 4.

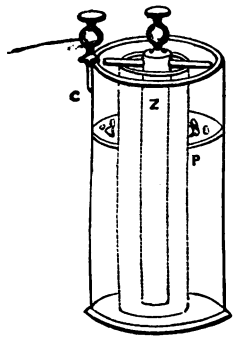
Z *Zinc.*
P *Porous cell.*
Pt *Platinum plate.*



BUNSEN'S BATTERY.

FIG. 5.

P *Porous cell.*
C *Carbon cylinder.*



DANIEL'S BATTERY.

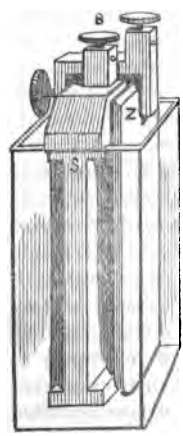
FIG. 6.

Z *Zinc rod.*
P *Porous cell.*
C *Copper cylinder.*

directions for the single cell process; the crystal shelf serves as a support for the porous tube, containing the dilute acid solution in contact with a cylinder of zinc suspended therein by a wooden rod, passing through a hole drilled near the upper extremity, and which rests on the edges of the porous tube. This battery is distinguished for its constancy of action to so high a degree, that it is known as the *constant battery*, a property of the highest importance in electrotyping; it also is continuous; if supplied with a sufficient store of crystals of sulphate of copper, the action lasts several days. If its greatest energy be required for a short period only, the acid solution in the porous cell should be in the proportion of one of acid to ten of water—if its constancy is the object, the solution should be very dilute. The exterior vessel may be of glass, or earthen ware, and lined internally with a sheet of copper to which the binding screw is soldered; or it may be covered with a coating of wax, blackleaded, and copper deposited thereon by the single cell arrangement. The two latter methods are preferable to the former, from the ease with which the deposited copper may be removed when it accumulates so as to interfere with the working. The diameter above given is that which has proved the best in practice; increase of active surface must therefore be obtained by addition to the height.

This form of battery, though it possesses great advantages over the former in the absence of noxious fumes, and the employment of cheaper materials, is nevertheless expensive when kept in constant work; waste of zinc by accidental splashings from the copper liquor, and consequent local action, infiltration through the porous diaphragm, and wear and tear of the latter, form heavy items in the expenditure where the work is extensive, and almost precludes its use in the factory.

43. Mr. Alfred Smee, to whom, as I have before observed, this art is indebted for the most lucid exposition of its laws, in seeking to remedy the many inconveniences attached to the other forms of battery, viz., the waste of zinc on the one hand by local action, and loss of power on the other by the obstinacy with which polished metallic surfaces retain the hydrogen, evolved according to laws previously enunciated, has devised a battery of the most simple construction, and which is maintained in action at a cost less than any yet described. On reference to the cut it will be seen to consist of a wooden frame carrying a plate of sheet silver roughened by friction between two sheets of sand paper, and covered with a deposit of platinum, either by immersing the silver in dilute sulphuric acid, to which a few drops of chloride of platinum solution has been added, and then connecting it with a piece of zinc within a



SMEE'S BATTERY.

FIG. 7

S *A frame holding the platinized plate.*
Z *One zinc plate.*
B *Binding screw attached to the silver.*

porous cell—or by heating a strong solution of platinum chloride, and passing the sheet silver through it. Either of these methods produces a surface full of microscopic asperities, eminently calculated to give off the bubbles of hydrogen as they form. On each side of the frame, and of equal superfices with the platinized plate, is a plate of amalgamated zinc, retained in its position by means of a large clamp screw, which has also an attachment for one of the connecting wires; the other being attached to the smaller screw, which descends through the wood framing, and is soldered to the negative plate: this latter should be of sufficient thickness to conduct the electricity readily, and of pure silver; one ounce should not exceed twenty-four inches in length by four in width (the usual width kept by the flatters). This battery is excited by sulphuric acid diluted with 10 parts of water—the mixture should be made and allowed to cool previously to immersing the battery in it; it is also of importance that the acid be free from nitric acid: this may be ascertained by its not bleaching a drop of sulphate of indigo thrown into it, as this falsification would in time attack the silver. Various metals have been tried as cheap substitutes for the silver, but none appeared to answer; electro-plated copper has also been used, but after a time the acid finds its way through the coating, and attacks the base metal.

44. A battery which is used by electro-platers on the large scale, is a modification of that known as Wollaston's battery; it consists of a rectangular piece of thick sheet zinc amalgamated, and a piece of sheet-copper double its size, bent in an inverted U form, thus (∩); a hole through the arch of the copper admits the assage of a connecting piece from the zinc, and a strip

from the same copper bent over serves for the other connection. The only claim this arrangement has to notice, is the ready means of putting it in action, and the low primary cost; the time required daily for brushing the copper free from the deposit before described, and the small power obtained, more than compensate, however, these minor advantages.

45. In the construction of galvanic batteries, it must be remembered, as a general rule, that the power is dependent upon the extent of surface of the negative element, whence radiation may take place to the positive surface.

This induces that property of the pile named *quantity*, which increases in direct ratio with the superficial extent. *Intensity*, on the other hand, is obtained by a combination of several single pairs, such as have been described, connected in the following manner, viz., the zinc element of one pair with the silver of another. *Quantity* is that property which enables us to cover a large surface with deposited metal. *Intensity*, that by which we overcome difficulties, such as those presented by refractory solutions, the cyanide of copper solution, for example, the conveyance of the current through a thin wire, a badly conducting metal, or we operate under circumstances such as exist in the case where some portions of the mould are at a long distance from the opposite pole, as in covering a mould of an alto-relievo. Intensity is also obtained by approximating as much as possible the negative and positive elements, and their respective terminals, when immersed in the solution undergoing electrotysis; and upon the strength of the acid liquid used, this, in the case of sulphuric, may be in the proportion of 6 water to 1 acid, mixed before pouring into the battery cell. In the use of the battery

process, the knowledge of the requisite proportion of these two powers is of the highest importance.

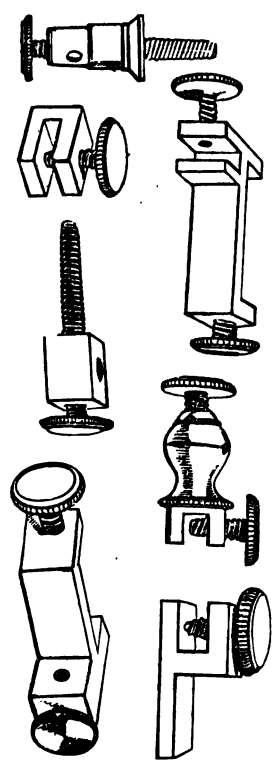
46. If on experiment it be found that one pair will cause a deposition of the metal from the solution under experiment, any increase in the number of pairs connected as above, will be only a waste of zinc, inasmuch as one *equivalent* of this metal will be dissolved in each separate cell for an equivalent of metal deposited.

The equivalent of a substance is the number which expresses the proportion by weight, in which it enters into chemical combination with others—thus, 32 parts of zinc combine with 8 of oxygen to form oxide of zinc, which in its turn unites with 40 of sulphuric acid to produce sulphate of zinc. 108 parts of silver would be necessary to form the corresponding salt of silver. And this law holds equally true with respect to the electro-deposition of metals; for 32 parts of zinc dissolved in each cell under the most advantageous circumstances may be deposited—28 iron, 32 copper, 108 silver, or 200 gold.

47. If, however, having several pairs, we wish to connect them so as to form a *quantity arrangement* to substitute for one large single pair, we arrive at this result by connecting the zincs of each separate pile together, and the silvers in like order, instead of alternating them as in the above-mentioned arrangement. Various binding screws have been designed for the convenience of insuring good metallic contact between the several pieces of apparatus above described. The following are the most generally useful.

47(*a*). Upon the relation existing between the power generated and the work to be performed, depends in a great measure success in the prosecution of Electrotype experiments. The mould should be, as nearly as is

convenient, of an equal superfices with the surface of the *negative element in each pair* of the battery. The



following laws, deduced from direct experiment both by Mr. Spencer and Mr. Smee, but more clearly enunciated by the latter gentleman, are sufficient to answer all requirements if their import be fully mastered.

1st. All metals can be reduced from their solutions by the aid of galvanic electricity.

2nd. Their deposition being effected by the hydrogen eliminated at the negative pole, if this be given off in a visible form (*i.e.* if there be a superabundance), the particles of metal will be deposited in a loose and incoherent manner, and the tenacity of the resulting mass vary from that of a mere aggregation of sand, or black powder. If, on the contrary, there be no production of free hydrogen, nor tendency thereto, the deposition of metal proceeds very slowly, and the molecules have time to arrange themselves in a perfectly crystalline form, possessing little

more tenacity than the black sandy deposit above described. When the relative electrical tension is such that no hydrogen is actually evolved, but the slightest increase of intensity would cause this to take place, circumstances are the most favourable to the production of pure reguline metal. The appearance of the copper produced under these favourable auspices need be seen but once to serve as a guide for future experiments; its beautiful rose tint is remarkable.

3rd. Increase or diminution of intensity is obtained by approximating or separating the poles of the battery, increasing or diminishing the quantity of acid contained in the exciting liquid in the battery cell; if the battery intensity be too great, it may be lowered by employing a very thin conducting wire, or employing a positive terminal in the form of wire, instead of a flat plate of metal.

4th. A weak acid solution is more readily decomposed than a saturated neutral one, and a hot liquor than a cold one.

48. Having constructed the battery, and furnished it with two conducting wires, a vessel is procured to contain the sulphate of copper solution (made as directed in a former portion of the treatise), the size of which may be regulated solely by the convenience of the operator. The mould (non-metallic previously blackleaded, and sufficiently weighted at the back with lead to prevent its floating), having a copper wire encircling it, or a ribbon of copper melted into its substance, and in contact with the plumbago, is attached to the wire from the zinc, and to the other wire is connected a piece of sheet-copper of a superfices equal to the mould, and as near thereto as is practically convenient.

49. The relative position in which these are placed

is of considerable importance; unless the mould be very large, it is usual to hang them vertically and parallel to each other; this causes the lower edge to be somewhat thicker than the upper, an accident easily remedied where a copy of a medal only is required, by reversing the position of attachment of its connecting wire when it is half finished. When, however, the subject is in deep intaglio or in high relief, or where absolute uniformity in the thickness of the stratum of copper is required, as for example in multiplying engraved copper-plates, the mould, having its conducting wire protected with sealing-wax varnish, is placed at the bottom of the decomposition cell, and the sheet of copper, enveloped in calico, supported by pieces of glass rod at from ¾ to 1½ inch above it; it will be evident that in the latter instance care must be taken to prevent the access of dust to the liquid under decomposition, as it would fall to the bottom and produce unsightly excrescences on the copper.

50. Very large non-metallic surfaces are sometimes difficult to cover entirely, certain small spaces obstinately resisting the extension of the copper. When this happens it is advisable to take the mould from the liquid, wash with clean water and allow it to dry, blacklead the spaces, and touch the part lightly with a thin *leading wire* connected with the wire of communication; if this be done with all due delicacy, it will scarcely injure the copper surface when detached from the matrix; at the same time, the superabundant growth of copper over the edges of the mould should be stopped out with varnish.

51. To separate a wax or non-metallic mould from the copper, warm the latter slightly by immersion for an instant in hot water, and remove the former as soon as it begins to appear soft and flexible, pulling it at

right angles to the surface; this may be facilitated by first turning back the overlapping edges with a blunt steel instrument; the edges being filed down, any remaining wax may be cleaned off by brushing with a hot solution of carbonate of soda, and the object bronzed and prepared as described in a former section. It is usually necessary to file down the edges of metallic moulds before they can be separated.

Instead of being bronzed, the medal may be gilt or silvered, by means hereafter to be described.

52. After a mould has been in the solution for some hours, it frequently becomes marked with striæ or streaks, extending *vertically* from any small speck of dust or small sharp prominence or depression on the mould. Their origin does not at present appear to be satisfactorily explained. I am inclined to lean towards the opinion that they originate in the escape of a little free hydrogen, commencing from the point and slowly finding its way to the surface, thus hindering the portion whereon it rests for the time being from becoming covered with deposited metal, as I have never seen these phenomena occur under circumstances where the power generated has been exactly equal to the work to be done, and there consequently has been no tendency to the generation of free hydrogen. When they occur it is necessary to agitate the solution, and to alter the position of the conducting wire, attaching it to another portion of the mould.

In an early portion of this treatise certain of the phenomena attendant on the reproduction of objects in copper were touched upon; more ample details may, however, not be superfluous, especially as in that instance attention was directed toward the use of a metallic mould.

53. *Non-metallic* moulds should be blackleaded immediately before being immersed in the solution, and the utmost care taken not to touch the surface after this operation; the plumbago should extend over the edges, so that the copper may have a firm hold of the mould, and be prevented from spontaneous separation, which it is apt to effect when taken out to be examined; this superabundant growth can be stopped by varnishing, or, *technically*, *stopping out*, when it has attained sufficient thickness; this usually occurs within six hours of being set in action.

54. Within three hours of placing the subject in the battery it should be carefully lifted out to be examined, the air-bubbles detached by blowing, the mould replaced, and not again disturbed for twelve hours; by this time the surface should be entirely covered; if this be not the case, it must be treated as described in Sec. 50. Under any circumstances this is the period for stopping out any superfluous growth, or making any alteration circumstances may require. Large medals do not usually attain the necessary thickness under the battery process in less than five or six days.

55. In cases where it is desirable to obtain considerable thickness and strength in the electrotype copy at a small outlay, it is usual to detach it from the mould, pare down the roughest edges, and, technically, *back it up* with soft solder. This is done by placing the medal, perfectly freed from copper solution and water, with its face downwards, on the ring of a retort-stand, putting on the back a drop or two of soldering liquor (made by dissolving zinc in hydrochloric acid, and adding to the liquor, when all action has ceased, one-fourth its weight of muriate of ammonia), then placing in contact with the moistened surface a stick of *tinman's solder* (a mix-

ture of tin and lead): this soon melts and attaches itself to the copper, and may be made to flow over the whole surface by retaining it in the fluid condition and *working* or *extending* it with the unmelted portion, until sufficient strength has been imparted. The application of this process to large subjects is, however, to be reprehended, as the heat employed renders the copper so soft as to bend in those portions not supported: for the latter it is necessary to use the workman's *copper bit*, placing the type on a flat surface covered by a non-conductor of heat: the manipulation of the above instrument can be readily acquired by five minutes spent in a tin-plate-worker's shop. Place now the medal between two sheets of gutta percha, slightly softened, in a vice, file off the superfluous edges, and mount it for the cabinet in any way fancy may dictate.

56. If it is required to connect the two faces so as to simulate the original medal, it is necessary to be careful, in forming the moulds, to impress each face sufficiently into the soft gutta percha to obtain an impression of the rim. When both are *backed up* and their edges properly filed, the two soldered surfaces must be laid together, kept in their proper position by binding screws, and heat applied until the solder is brought to the melting point; the screws may be now tightened a little, the superfluous solder escapes at the edges, and when these are brought into perfect juxtaposition it may be allowed to cool. Nothing more is now required than to file off any superabundant soft metal, and bronze the medal. By throwing a slight coating of silver over it, the junction of the two edges is effectually concealed: or the rim only can be coppered, by connecting the medal with the zinc element of a *two-pair battery*, and rotating it in contact with the surface of a cupreous

cyanide solution in which the copper positive terminal is immersed. The method of making the latter solution will be detailed in its due place.

VARIOUS APPLICATIONS OF ELECTROTYPE.

57. *Busts* and *statues*, in plaster, wax, or other non-metallic substance, may be covered with a thin coating of reduced copper without materially detracting from their original sharpness, and thus rendered capable of exposure to the influence of the weather or such friction as would destroy the softer material. The mode of effecting this is by saturating it, if porous, with wax as before described; if not porous, immediately metallizing by methods described in sec. 37 and 38, and after attaching leading wires to several parts, particularly the deep-seated portions, place it in the copper solution *contained inside the porous cell*, if the single-cell arrangement is used, or in the decomposition cell if the battery process be employed: the latter is the more preferable method, as in the former the deep cut parts, being so much further removed from the source of electricity than the higher portions, progress so much more slowly —and hence there is great risk of their not covering. In the battery process, on the contrary, leading wires can be attached to any portion after the subject is immersed, if a glass cell be used, and the action on any particular spot may be quickened or relaxed at pleasure by increasing or diminishing the distance of the position pole, which may, for convenience, be divided into several portions.

58. The following method of obtaining a facsimile of a statue, though troublesome in practice, produces an excellent result. Make an elastic mould thereof by the

means described in sec. 35. Pour into the hollow thus obtained the phosphorized wax in sec. 38-1, detach the wax statue thus obtained, metallize it, and employ it to obtain a copper matrix by covering it with a thin coating, as above, melting out the wax, and using the matrix as the vessel wherein to pour the copper solution; suspend therein a porous cell with zinc, and, when supposed to be sufficiently thick, fill it in with plaster and peel off the outside covering.

59. Objects illustrative of natural history, such as fruits, leaves, simple flowers, mosses, ferns, &c., may be covered with a thin pellicle of copper, by being first blackleaded or metallized by the process above described (sec. 38). Bouquets of grass and small evergreens first coated with *reguline* copper, and then with *crystalline*, by changing them to a saturated perfectly neutral solution, have a very pleasing and brilliant effect, the facets of the crystals reflecting light in all directions. Their brilliancy can only be retained by the following manipulation: as they are taken from the copper solution, let them be washed perfectly from all traces thereof by a gentle stream of water, dipped into boiling distilled water, and when dry placed under a glass shade.

60. Compass-boxes, being hollow hemispheres of copper or brass, are best produced by the electrotype process. The metal deposited being perfectly pure prevents the aberration of the needles produced sometimes by particles of iron or nickel, the two magnetic metals, accidentally present in the ordinary commercial metal.

61. Printing type faced with electro-copper has been employed, and found to last very much longer than those in general use. Three papers are now published in the city of New York printed with this type and it is said the duration thereof is three times that of the ordinary.

62. Chemical vessels coated externally with copper are found exceedingly useful for a variety of purposes. Want of attention to a proper principle of application has, however, restricted their employment within a sphere much more limited than was anticipated. The process applies well to condensers, receivers, &c., and is also well adapted for flasks or retorts; but care must be taken always to keep the liquid in the interior some distance above the line marking the edge of the copper, as its good conducting property, were this precaution omitted, would cause the glass to become hot in that part, and render its breaking, from splashing of the *comparatively* cooler liquid, almost inevitable. A metallic surface is given to the glass by first roughening the exterior by hydro-fluoric acid, and when dry, blackleading, the asperity produced by the acid being sufficient to retain the plumbago; or, the vessel being previously filled with boiling water, it may be dipped into a solution of nitrate of silver containing five grains in the ounce, and mixed with a small quantity of formiate of soda, thus reducing metallic silver on the surface. If the single-cell process be here adopted, the vessel to be covered must be contained within the porous cell.

63. A valuable application of the Electrotype process has been lately patented. It consists in the manufacture of door and window plates, at a cost very inferior to the present method, viz., engraving letters on a stout plate of brass, zinc, &c., and either leaving them hollow or filling up the depressions with wax. The process is conducted in the following manner: a plane surface (in preference one of copper) is procured similar in size to the desired plate; separate letters, in any material, metallic or otherwise, are then placed thereon with their faces downwards, and their positions reversed, as in

composing type: and caused to adhere slightly to the copper by an oil varnish, grease, &c.; the whole are then blackleaded and submitted to the battery operation, until sufficient thickness of deposit is obtained; on separating the two plates, the electrotype will be found to consist of a smooth polished surface, having the letters firmly imbedded therein. This principle is capable of many valuable and pleasing modifications. The plate serving as matrix, may have an *Engraver's ground* thrown over it; the portions thereof, where the letters are desired to be, removed by any known method, so as to lay bare the surface of the copper. On placing this in the decomposition cell, the metal will be deposited only where the letters are situate, and may be silver, brass, or any other. On clearing off the ground subsequently by means of oil of turpentine, copper may be deposited in the manner explained above. Or the letters may be laid on in any thick paint, allowed to dry, and then blackleaded; the plate on being taken off will present depressions where the painted letters were situate, which may be filled up with coloured wax, and thus perfectly simulate the present engraved plates.

64. Since the foregoing pages were written, the following method of producing moulds from undercut objects and those in high relief has been communicated by the kindness of a friend. Melted glue is poured over the surface of the object, oiled and laid horizontally, and carefully wiped by means of a soft brush, into every depression: it is allowed to set, and then carefully detached therefrom. It is now placed for a few minutes in a strong solution of a neutral salt of alumina; this liquid, on being made to penetrate every crevice, hardens the exterior surface, and renders it superficially insoluble in water: it should then be dried and metallized by any of those

methods described in former sections: those depending upon the precipitation of metallic silver are the more preferable.

65. A plan of avoiding air bubbles, in this as well as other similar operations, which I have found very successful, is the following:—Before connecting the mould with the battery, place it horizontally in a flat dish, cover its surface to the depth of one quarter of an inch with the copper solution, and drive away air bubbles by directing a slender stream of the liquor over its whole extent, by means of a glass syringe or pipette (a glass tube drawn out to a point at one extremity, and having an enlargement at its centre serving as a reservoir); on blowing through it with the mouth, a strong current of the contained liquid may be directed into the deepest crevices. I have found this answer so well that I have covered objects of many hundred square inches and much undercut, without a single air bubble.

66. Gutta Percha mixed, by boiling in water, with one fourth of white wax, has been found to answer well as a material for mould making; it softens readily below the temperature of boiling water, and retains this consistence longer than the native gutta, whilst when cold it appears to retain the same degree of hardness: it also *takes* the blacklead as well as the raw material.

67. The brushings from the zinc, battery plates, and the deposit which accumulates within the battery and the porous cells contain much mercury; they should be saved until a large quantity has accumulated, then dried and distilled over into a receiver containing water from an iron or earthenware retort; for small quantities the heat of an ordinary fire is sufficient.

LIST OF PRICES

OF

ELECTROTYPE APPARATUS,

MANUFACTURED BY

J. B. HOCKIN & CO.,

OPERATIVE CHEMISTS,

289, STRAND, LONDON.

Single Cell Apparatus:

	£	s.	d.		£	s.	d.
Fig. 1, page 6					0	3	6
„ 2, „	0	8	6	to	0	12	6
„ 3, „	1	1	0	„	3	0	0
Smee's Batteries, page 32	0	5	6	„	0	10	6
Daniell's, „ „ 31	0	4	6	„	0	7	6
Bunsen's „ „ 30	0	3	6	„	0	10	6
Groves's „ „ „	0	5	6	„	1	0	0

Decomposition Cells of any Dimension.

Porous Slabs, 12 × 14 inches	0	6	0	
Apparatus for Silvering Daguerreotype Plates	0	15	0	& upwards.
White Porous Cylinders above 4 inches high	0	0	1	per inch.
Flat Porous Cells 6d., 10d., 1s., and	0	1	8	
Binding Screws from 4d. to	0	1	0	each.
Platinised Silver, 4 inches wide and 21 inches to the ounce In length	0	0	6	per inch.

	s.	d.		s.	d.
Wax Composition . per lb.	2	6	Cyanide Potassium . per oz.	0	6
Gutta Percha, pure „	2	6	Brushes . . . . . each	0	6
Ditto, and Wax . . . „	3	0	Nitrate of Silver . . per oz.	5	0
Plumbago . per box, 3d. and	0	6	Sheet „ . . . „	7	6
Sulphate of Copper . per lb.	0	6	Silver Solution, per pint, 5s &	8	0
Solution of Phosphorus, per oz.	0	6	Gold „ . . . per oz.	2	0
Sulphuric Acid . . . per lb.	0	3	Zinc Plate . . . . per lb.	0	8
Hydrochloric „ . . . „	0	3	„ Rod . . . . . „	0	8
Nitric „ . . . „	1	0	Fusible Metal . . . „	3	6
Mercury . per lb., 5s.; per oz.	0	6			

Moulds of all Sizes, in Wax and Gutta Percha, &c.

Electrotyping in all its Branches,

And Instructions given therein, either to the Amateur or those intending to pursue it as a Business.

PHOTOGRAPHIC APPARATUS, AND PURE CHEMICALS OF ALL DESCRIPTIONS.